

Trans Fatty Acids: Are the Effects Only Marginal?

Walter C. Willett, MD, DrPH, and Albert Ascherio, MD, DrPH

ABSTRACT

In the process of converting vegetable oils into solid fats, a process known as partial hydrogenation, some unsaturated bonds are converted to an unnatural *trans* position. In humans, *trans* fatty acids increase low-density lipoprotein cholesterol and decrease high-density lipoprotein cholesterol. In addition, positive associations between intake of *trans* fatty acids and coronary heart disease have been observed in epidemiological studies. The combined results of metabolic and epidemiological studies provide strong evidence that *trans* fatty acid intake is causally related to risk of coronary disease. Because the consumption of partially hydrogenated fats is almost universal in the United States, the number of deaths attributable to such fats is likely to be substantial. Federal regulations should require manufacturers to include *trans* fatty acid content in food labels and should aim to greatly reduce or eliminate the use of partially hydrogenated vegetable fats. (*Am J Public Health*. 1994;84:722-724)

At the turn of the century a process was discovered that uses heat in the presence of hydrogen and certain metal catalysts to convert natural liquid vegetable oils into solid fats.¹ This change in physical state occurs because some unsaturated bonds become saturated (fully hydrogenated) and others are converted from their natural *cis* to the *trans* position, creating straight molecules that pack together more solidly. Many of these molecules have never been encountered in nature. This process of partial hydrogenation was rapidly commercialized to create vegetable shortening, containing 30% to 40% *trans* fatty acids, at a cost lower than that of lard or other animal fats. Even by about 1910, per capita production of margarine and vegetable shortening was above 4 kg per year. Production rose steadily over the course of the century, further augmented by the substitution of margarine for butter, for both economic and purported (but undocumented) health benefits. Even though partially hydrogenated fats have continued to displace animal fats, per capita consumption of *trans* fatty acids from vegetable sources declined slightly from a peak of about 2.2% of calories in the 1960s because the level of hydrogenation was decreased to retain more of the original polyunsaturated fats. In the mid-1980s, consumption of *trans* fatty acids was estimated to average about 2.1% of total energy, although individual intakes can vary widely depending on food choices.

In the last several years major changes in *trans* fatty acid intake have occurred. Cooking oils were no longer partially hydrogenated after about 1985, and the major fast food chains switched from beef tallow to heavily hydrogenated oils containing 25% to 35% *trans* fatty acids for deep frying.² Also, an expensive public relations campaign by the US soybean

industry effectively displaced palm oil (a natural solid fat) with partially hydrogenated fats in innumerable processed foods. The profound increase in the use of partially hydrogenated fats over this century in the United States is now also being experienced by many Third World countries undergoing a transition from subsistence agriculture. In parts of India, for example, a partially hydrogenated vegetable fat containing more than 60% *trans* isomers is used to replace ghee (clarified butter), and elsewhere heavily hydrogenated fats designed to remain solid under tropical conditions have become basic food commodities.

Much of the success of *trans* fatty acids is due to the economic appeal of their longer shelf life and decreased expense compared with other fats. However, products containing *trans* fatty acids, especially margarine, have been heavily promoted on the basis of health claims. Such claims have never been substantiated; indeed, over many years, concerns have been expressed regarding possible adverse health effects of *trans* fatty acids. These concerns have arisen because these isomers are structurally similar to saturated fats, completely lack the essential metabolic functions of their parent polyunsaturated fats, and compete with the essential fatty acids in complex metabolic

The authors are with the Departments of Nutrition and Epidemiology, Harvard School of Public Health, Boston, Mass. Walter C. Willett is also with Channing Laboratory, Department of Medicine, Harvard Medical School and Brigham and Women's Hospital, Boston.

Requests for reprints should be sent to Walter C. Willett, MD, DrPH, Department of Nutrition, Harvard School of Public Health, 665 Huntington Ave, Boston, MA 02115.

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pathways.³ Also, consumption of partially hydrogenated vegetable fats has tracked closely in time with the epidemic of coronary heart disease in the United States and elsewhere.⁴ *Trans* fatty acids have increased serum total cholesterol levels in some, but not all, metabolic studies.⁵ A more general concern is that a major artificial element has been introduced into the food supply without a full understanding of all its metabolic and health implications. A report issued in 1985 did not find clear evidence that *trans* fatty acids were harmful, but it did indicate the need for further research.⁵

Recently, substantial new data on the health effects of *trans* fatty acids have become available. These findings are based on human metabolic studies of blood lipoprotein fractions (rather than just total serum cholesterol) and epidemiological studies relating intake of *trans* fatty acids to risk of coronary heart disease. In a seminal metabolic study, Mensink and Katan demonstrated that *trans* fatty acids increased low-density lipoprotein (LDL) cholesterol to a similar degree as did saturated fats.⁶ In contrast to other forms of fat, however, *trans* isomers decreased high-density lipoprotein (HDL) cholesterol; thus, the increase in the ratio of total cholesterol to HDL cholesterol for *trans* fatty acids was approximately double that for saturated fats. Similar adverse effects were confirmed in other studies.^{7,8} Unlike other fats, *trans* fatty acids were found to increase lipoprotein(a), another putative risk factor for coronary heart disease, in two of three studies.^{8,9}

Positive associations between intake of *trans* fatty acids and coronary heart disease have been observed in several epidemiological studies. Thomas et al. found higher levels of *trans* fatty acids in the adipose tissue of persons dying of myocardial infarction than in the tissue of persons with other causes of death.¹⁰ In a prospective study of nearly 90 000 women, intake of *trans* fatty acids from partially hydrogenated vegetable fats was associated with risk of myocardial infarction. The risk of women in the highest quintile of intake (median intake = 3.2% of total energy) was 1.8 (95% confidence interval = 1.1, 2.8) times that of women in the lowest quintile (median intake = 1.3% of total energy) after adjusting for standard risk factors and excluding those who had greatly increased or decreased their intake of margarine over the previous 10 years.¹¹ This risk is quantitatively higher than would be predicted by the effect of *trans* fatty acids on blood lipids, which is

compatible with the suggestion that *trans* fatty acids may have other adverse physiologic effects, perhaps mediated by a prothrombotic mechanism.¹² A similar positive association between intake of *trans* fatty acids and risk of myocardial infarction was observed in a case-control study of men and women,¹³ and a positive association between blood levels of *trans* fatty acids and coronary narrowing was found in a cross-sectional angiographic study.¹⁴

Level of Evidence for Causality

The recent metabolic and epidemiological data provide a complementary body of evidence indicating adverse health effects of *trans* fatty acid consumption. The epidemiological data alone might be regarded as inconclusive because confounding by unmeasured variables is always possible, but the metabolic data give strong support for a causal interpretation. Some have questioned the interpretation of the conclusive evidence that *trans* fatty acids have adverse effects on blood lipids,¹⁵ but the epidemiological findings support the interpretation that, as expected, higher intake of *trans* fatty acids increases the risk of coronary heart disease. Like the tobacco industry, the oil processing industry claims that a cause-and-effect relationship cannot be established without a randomized trial,¹⁶ which is of course ethically and logistically impossible. Indeed, in this country further epidemiological studies will be difficult because the food sources of *trans* fatty acids have changed so dramatically over the last several years, such that even persons with stable diets will not have had stable *trans* fatty acid intakes.

Although we do not have fully conclusive evidence that *trans* fatty acids cause coronary heart disease, prudence suggests that we adopt a low threshold for evidence of harm for synthetic substances added to the food supply that have no known nutritional benefit. Further, it should be the responsibility of those who manufacture and sell an artificial food to show that the product is safe. We believe that the threshold of evidence for harm has been far surpassed in this case; the metabolic data alone should be a sufficient basis for limiting human intake of partially hydrogenated vegetable fat, and the epidemiological data provide further weight. A comparison with the regulation of potential carcinogens in the food supply indicates a gaping double standard. Chemical additives are disallowed

even in trace amounts that have no observable effects in humans and that, by mathematical modeling, might theoretically cause only a small number of cancers.

Quantitative Estimates of Risk

One estimate of the effect of *trans* fatty acids can be obtained by combining the effect of *trans* fatty acids on the ratio of total cholesterol to HDL cholesterol¹⁶ and the relationship between this lipid ratio and coronary heart disease risk.¹⁷ If 2% of energy is consumed in the form of *trans* fatty acids from partially hydrogenated fat (approximately the US average), the increase in the lipid ratio is about 0.14, for a relative risk of 1.07 (attributable risk of about 7%). This is likely to be an underestimate because the relationship between blood lipids and coronary heart disease risk was determined from a single blood specimen at one point in time. If data from the Nurses' Health Study are used, the estimated attributable risk would be about 35%. Although the percentage of coronary heart disease deaths in the United States attributable to intake of *trans* fatty acids is uncertain, even the lower estimates from the effects on blood lipids would suggest that more than 30 000 deaths per year may be due to consumption of partially hydrogenated vegetable fat. Furthermore, the number of attributable cases of nonfatal coronary heart disease will be even larger.

Alternatives to Trans Fatty Acids

Are there alternatives to the use of partially hydrogenated vegetable fats in our diets? Obviously, the answer is yes—such fats did not even exist until very recently. The evidence suggests that vegetable fats are best consumed in their natural unhydrogenated form, and that a balance of polyunsaturated and monounsaturated fatty acids is most desirable.¹⁸ The processed oil industry has argued that *trans* fatty acids only replace solid saturated fats,¹⁶ but this is not necessarily true. Unhydrogenated vegetable fats can be used in many of the frying and baking applications where partially hydrogenated fats are currently used (although more care is sometimes needed to maintain freshness and avoid burning), and olive or sesame oil can be used at the table. Some will still prefer solid fats for certain purposes. The occasional use of butter or lard will not have any important effect on health, and the fatty acid composition of lard and beef tallow, which contain mainly

unsaturated fats, may not be as unhealthy as generally believed. We now have newer knowledge about the effects of specific fatty acids on lipoprotein fractions.¹⁹ Although the health effects of palm oil need to be studied further, the saturated fat in this product has a less adverse effect on blood lipids, as assessed by the ratio of total cholesterol to HDL cholesterol, than do *trans* isomers. Moreover, margarines and shortenings can be made without *trans* fatty acids; these products are generally available in Europe, although not in the United States. Thus, there appear to be many ways to avoid *trans* fatty acids; the healthiest would require some individual changes in eating style, but others would be imperceptible to consumers.

Policy Options

What is the responsible public health response? One option would be to eliminate or greatly reduce the amount of artificial *trans* fatty acids in the food supply. The food industry could voluntarily phase out the production of *trans* fatty acids, but at present US producers are resisting even the acknowledgment that their products have adverse effects. Thus, a voluntary phaseout is unlikely, although in Europe the largest producer has publicly committed to reducing the *trans* isomer content of its products (O. Korver, Unilever, written communication, February 10, 1994). An alternative, of course, is a Food and Drug Administration (FDA) ban on or strict regulation of *trans* isomers in foods. As is true for low-level radiation, a truly inconsequential level of *trans* fatty acid intake is almost impossible to establish. Low levels of *trans* fatty acids are found in butter and beef fat (levels are about 5%, but the fatty acids are somewhat different in structure and function from those in partially hydrogenated fats).

A complementary approach would be to label foods as to their *trans* isomer content. The new labeling act effective in May 1994 requires labels to include the amount of saturated fat.²⁰ If the *trans* fatty acid content is not required on labels, food processors are likely to increase the content of these isomers in their products because they provide the same physical properties while decreasing the amount of saturated fat. In Canada, products labeled "low in saturated fat" have very high

levels of *trans* fatty acids.²¹ Some have suggested that *trans* fatty acids be included with the saturated fat on the label. While certainly better than ignoring *trans* fatty acids, this practice would be scientifically incorrect and would not recognize the metabolic and epidemiological evidence that *trans* fatty acids seem to have a greater adverse impact than saturated fats. We have been told by an FDA official that consideration was given to including *trans* isomers on food labels but the idea was discarded, in part because focus group participants did not recognize the term. This argument seems weak: the topic is new, and the public is capable of learning new terms and their meanings. A major limitation of the current food labeling requirements is that many products, including fast foods, which often contain extremely high amounts of *trans* isomers, are exempt. Moreover, these foods often carry egregiously deceptive labels such as "cholesterol-free" and "cooked in vegetable oil." Thus special warning labels should be used on these products, indicating that they were prepared with partially hydrogenated vegetable fat. Such warning labels are, indeed, more justifiable than those on cigarettes and alcoholic beverages, because the nature of the product is invisible to the consumer.

We favor a regulated phaseout or strict limitation of partially hydrogenated fat in the US diet. Short of such regulation, labeling requirements that include fast foods should be implemented immediately. □

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